doi:10.1017/S1431927610055431
Microsc. Microanal. 16 (Suppl 2), 2010

Investigation of Baddeleyite Phase Found in Martian Meteorites

Jian Li[1], Tom Malis[1] and C.D.K Herd[2]

[1] Materials Technology Laboratory, CANMET, 568 Booth St. Ottawa, Ontario, Canada, K1A 0G1
[2] Department of Earth and Atmospheric Science, 1-26 Earth Sciences Building, University of Alberta, Edmonton, AB, Canada T6G 2E3

Baddeleyite (ZrO_2) is a mineral phase important for determining U-Pb ages of rock samples. However, baddeleyite in meteorites from Mars have been affected by impact shock during their time on the Martian surface. A primary question is whether baddeleyite is able to maintain a record of its U-Pb age after undergoing extremes in pressure. Experiments by Niihara et al. [1, 2] showed no change in Phalaborwa baddeleyite even at shock pressures of 57 GPa where the surrounding basaltic matrix was at least partially molten. Based on these studies, it is can be assumed that baddeleyite in Martian meteorites at least remains closed to resetting of U and Pb.

Despite the significant interest to characterize the baddeleyite found in Martian meteorites, its relatively small grain size and extremely low volume fraction has limited the investigations to very few analytical techniques like LA-MC-ICP-MS [3] and SHRIMP II instrument [4]. Such analysis, although capable of extracting useful chemical composition information and preliminary U-Pb ages of baddeleyite, does not provide any microstructure details, which could provide insights into the effects of shock on the mineral.

Focused ion beam microscopy (FIB) has been widely used in high-resolution ion beam imaging and site-specific TEM specimen preparations in the past years [5-6]. In this study we report using the FIB technique to prepare a planview TEM specimen from a Martian meteorite (NWA3171). The electron transparent thin foil contains the very small baddeleyite phase identified by SEM EDS analysis. As shown in Figure 1, baddeleyite phase as identified by SEM (1a) is coated with a thin layer of metallic tungsten using FIB precision micro-deposition (1b). Once the area around is milled, it is then lifted out and mounted onto a TEM copper grid (1c). FIB secondary electron image shown in Figure 1d shows one-to-one correlation of the baddeleyite phase on the substrate prior to the liftout process. Subsequent analyses using a Philips CM-20 TEM indicate that this baddeleyite phase has recrystallization on a nano/microscale, but a monoclinic crystal structure. The Phase-Temperature phase diagram for ZrO_2 shows that baddeleyite remains as monoclinic at temperatures less than 1000 °C and pressure less than 4 GPa [7]. The current study showed no evidence for preserved high-pressure polymorphs in the sub domains, although more detailed TEM work is forthcoming. Our observations are consistent with previous studies [2] using Raman analysis, that shock metamorphism does not result in polymorphic phase transformations in baddeleyite. We can conclude that baddeleyite remains a useful prospect for U-Pb ages of Martian meteorites.

REFERENCES

[1] Niihara T. et al. (2009) *M&PS, 44*, A157.
[2] Niihara T. et al. (2009) *LPS XL,* Abstract #1562.
[3] Herd C.D.K. et al. (2007) *LPSXXXVIII*, Abstract #1664.
[4] Ozawa S. et al. (2009) *AGU Fall Meeting*.
[5] Jian Li, *Journal of Metals, vol.58 No.3,* 27-31, 2006.
[6] Jian Li, T. Malis and S. Dionne, *Journal of Materials Characterization*, *vol. 57*, 64-70, 2006.
[7] Ohtaka O. et al. (2001) *Physical Review B, 63*, 174108

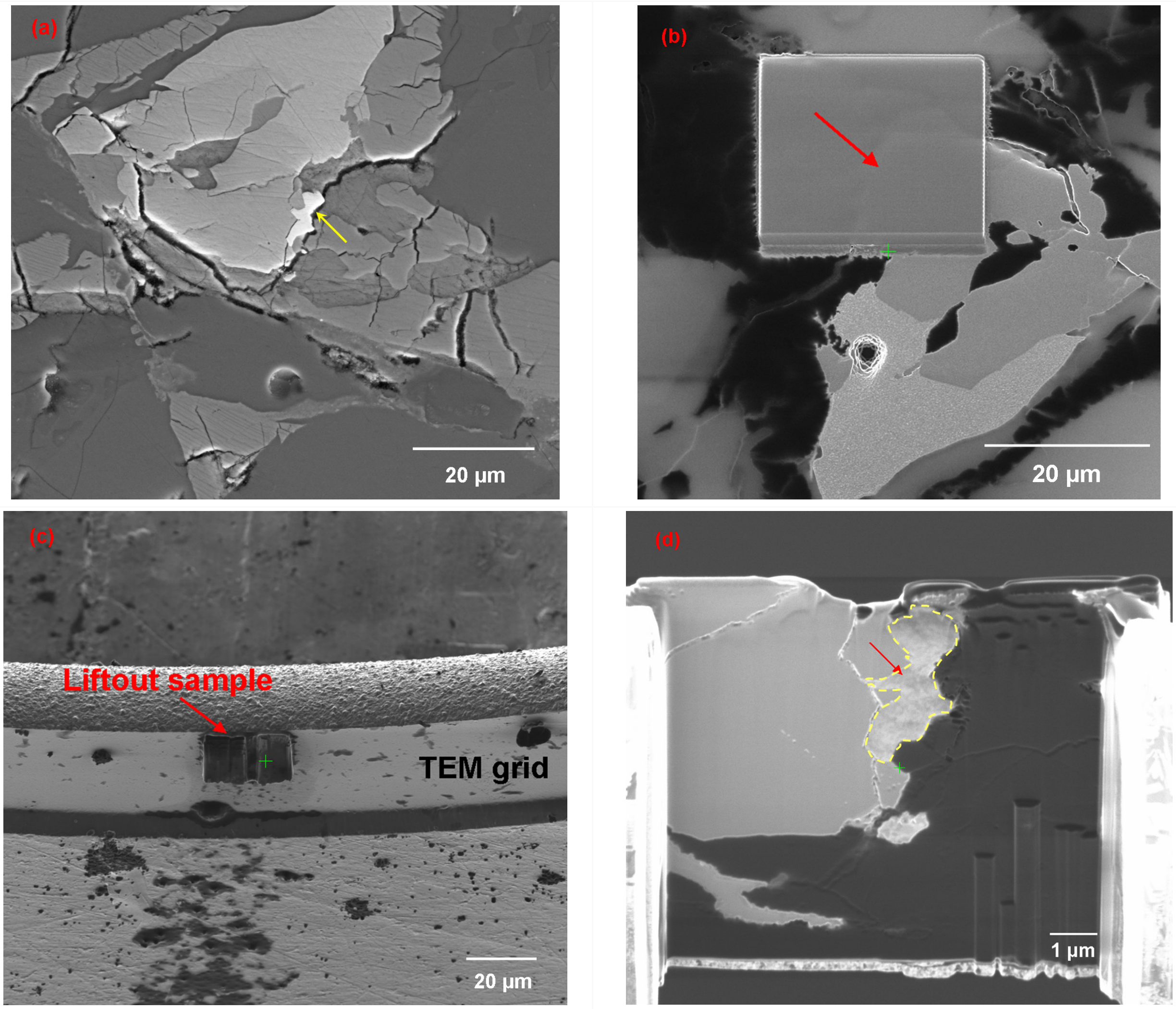

Figure 1. FIB TEM specimen liftout process. (a). baddeleyite phase identified on the polished thin section, (b) FIB deposited W to protect the baddeleyite phase from ion beam damaging, (c) The protected zone containing the baddeleyite phase cut free, lifted out and mounted on TEM grid, (d) FIB thinning specimen showing the retained baddeleyite phase.

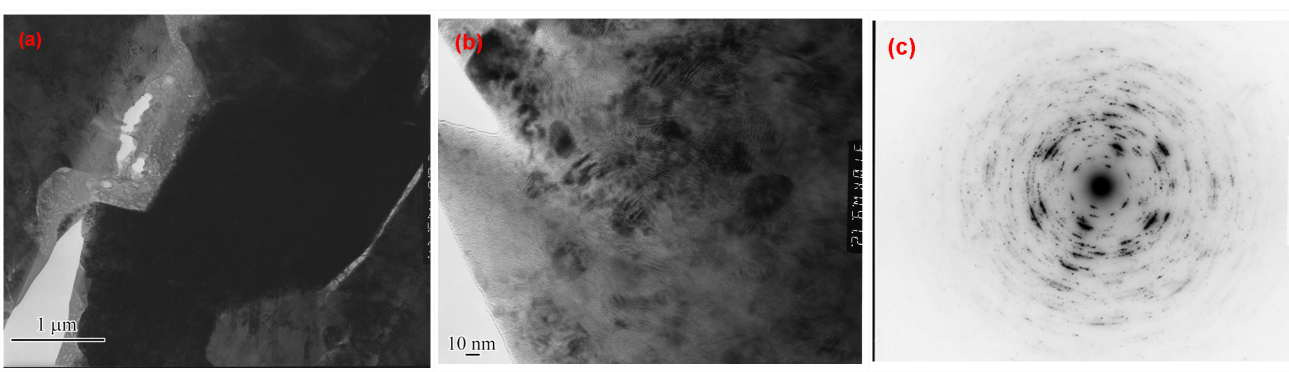

Figure 2. (a), (b) bright field TEM images, (c) SADP indicating that the ZrO_2 has monoclinic symmetry

https://doi.org/10.1017/S1431927610055431 Published online by Cambridge University Press